# MODEL 303

Ballantine

# Ballantine

# MODEL 303

# AC VOLTMETER

## WITH

## OPTIONAL VARIATIONS

**BALLANTINE LABORATORIES, INC.**

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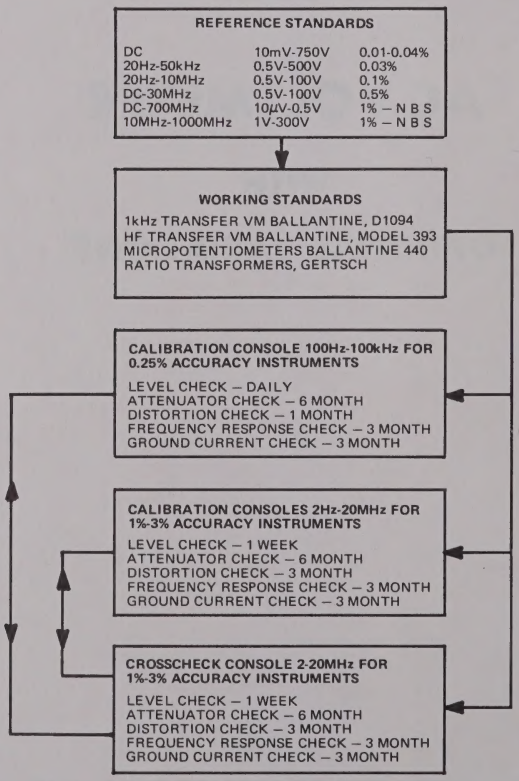
REFERENCE STANDARDS
DC 10mV-750V 0.01-0.04%
20Hz-50kHz 0.5V-500V 0.03%
20Hz-10MHz 0.5V-100V 0.1%
DC-30MHz 0.5V-100V 0.5%
DC-700MHz 10μV-0.5V 1% – N B S
10MHz-1000MHz 1V-300V 1% – N B S
WORKING STANDARDS
1kHz TRANSFER VM BALLANTINE, D1094
HF TRANSFER VM BALLANTINE, MODEL 393
MICROPOTENTIOMETERS BALLANTINE 440
RATIO TRANSFORMERS, GERTSCH
CALIBRATION CONSOLE 100Hz-100kHz FOR 0.25% ACCURACY INSTRUMENTS
LEVEL CHECK – DAILY
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 1 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH
CALIBRATION CONSOLES 2Hz-20MHz FOR 1%-3% ACCURACY INSTRUMENTS
LEVEL CHECK – 1 WEEK
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 3 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH
CROSSCHECK CONSOLE 2-20MHz FOR 1%-3% ACCURACY INSTRUMENTS
LEVEL CHECK – 1 WEEK
ATTENUATOR CHECK – 6 MONTH
DISTORTION CHECK – 3 MONTH
FREQUENCY RESPONSE CHECK – 3 MONTH
GROUND CURRENT CHECK – 3 MONTH

*Ballantine's Quality Assurance program satisfied the requirements of MIL-Q-9858.*

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# FOR
# MODEL 303 AC VOLTMETER
## WITH OPTIONAL VARIATIONS


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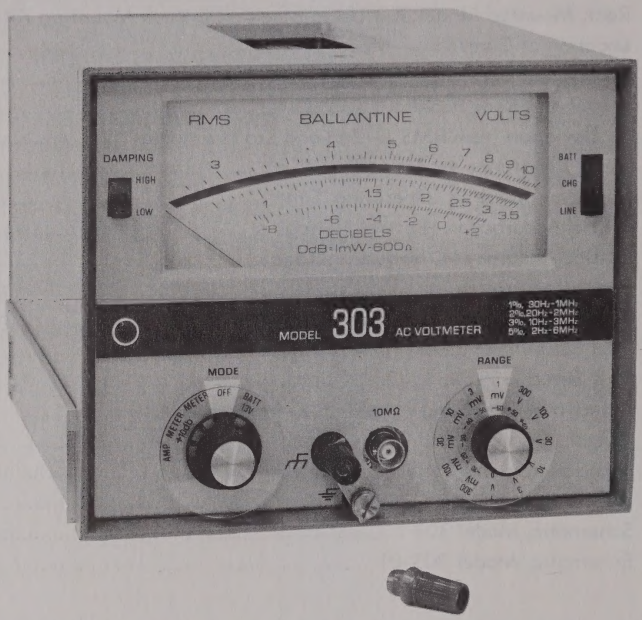



**Fig. 1. Ballantine Model 303 AC Voltmeter**

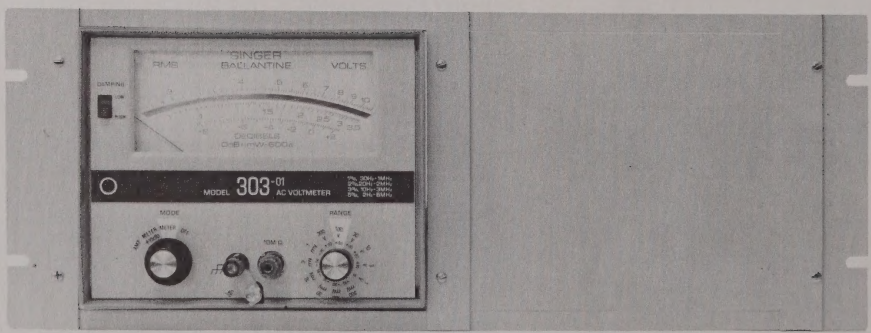



**Fig. 2. Rack Mounted Model 303 Using Model 800 Rack Mounting Kit**

# 1. GENERAL INFORMATION

## 1.1 Description

The Ballantine Model 303 is a portable, general purpose, solid state AC Voltmeter. It is available in several versions:

| | |
|---|---|
| Model 303 | Operates from rechargeable battery or line. |
| Model 303-01 | Operates from line only. |
| Model 303-50 | Operates from rechargeable battery or line. Model 1303 20 dB Probe supplied. |
| Model 303-51 | Operates from line only. Model 1303 20 dB Probe supplied. |

The basic instrument covers the frequency range from 2 Hz to 6 MHz and voltages from 100 $\mu$V to 300 V with a midband accuracy of $\pm 1\%$ of indication. It responds to the average value of the input signal but is calibrated to indicate the rms value of a sine wave.

The taut band logarithmic indicator has a 5" long mirror-backed scale. The logarithmic scale provides constant resolution for all indications. A linear dB scale allows direct conversion of voltage ratios to decibels without reference to charts or tables.

A three-terminal unsymmetrical 10 M$\Omega$ input permits grounding the instrument case independent of the signal ground. The signal connection is through a type BNC connector which gives complete shielding of the input and low impedance ground paths when coaxial input cables are used. A Model 618 Binding Post Adapter is supplied to convert the coaxial input to ¾" spaced binding posts.

Great emphasis is placed on the reliability and life of the voltmeter. The transistors and other components are conservatively operated. The proper amount of feedback and a conservative accuracy specification insure that the great majority of voltmeters will meet specifications for several thousand hours of normal laboratory use without recalibration.

## 1.2 Applications

General voltage measurements in grounded and isolated circuits.

Signal tracing and frequency response checks in audio and video circuits.

Power line monitor (Battery operation recommended).

Frequency response checks in instrument type servo systems.

General field use as a battery operated portable instrument.

Battery operated wide band preamplifier with negligible power line pickup.

## 1.3 Technical Characteristics

| | Models 303 and 303-01 without Probe | Models 303-50 and 303-51 with Model 1303 Probe |
|---|---|---|
| **Voltage** | 300 $\mu$V - 350 V (12 ranges) | 3 mV - 1000 V (11 ranges) |
| Lowest indication in "METER +10 dB" Mode | 100 $\mu$V (10 Hz - 1 MHz) | 1 mV (100 $\mu$V without Probe) (10 Hz - 1 MHz) |
| dB V Range | −70 to +50 | −50 to +60 |
| **Frequency** | 2 Hz - 6 MHz | |
| 3 dB Bandwidth | 1 Hz - 10 MHz | |
| **Accuracy on all ranges except "METER +10 dB" Mode, % of Indication, Reference Conditions** | 1%, 30 Hz - 1 MHz<br>2%, 20 Hz - 2 MHz<br>3%, 10 Hz - 3 MHz<br>5%, 2 Hz - 10 Hz<br>5%, 3 MHz - 6 MHz (to 35 V, 35 - 350 V)<br>10%, 3 MHz - 6 MHz | to 350 V, 350 - 1000 V |
| **Accuracy, "METER +10 dB" Mode, % of Full Scale, Reference Conditions** | 1%, 100 Hz - 100 kHz<br>2%, 50 Hz - 200 kHz<br>3%, 20 Hz - 500 kHz<br>5%, 10 Hz - 1 MHz | |

**1.3 Technical Characteristcs (continued)**

| | Models 303 and 303-01 without Probe | Models 303-50 and 303-51 with Model 1303 Probe |
|---|---|---|
| **Reference Conditions** | Line Voltage — 120 V ±2%<br>Line Frequency — 50 - 400 Hz, ±1%<br>Warmup — 1 hour<br>Temperature — 25°C ±3°C | |
| **Stability**<br>Temperature | 0 - 50°C — additional uncertainty ½ of specified accuracy | |
| **Stability**<br>Line Operation | Warmup Time — Usable after 30 s, full accuracy after 10 min.<br>Effect of 10% Line Voltage Change < 1/5 of stated accuracy | |
| **Stability**<br>Battery Operation | Battery Voltage of 14.5 - 16.0 V — Full accuracy<br>13.0 - 17.0 V — Accuracy derated two times | |
| **Max Continuous Input**<br>DC<br>< 10 kHz<br>> 10 kHz | <br>600 V<br>350 V<br>ranges > 35 mV, 350 V<br>ranges < 35 mV, 35 V | <br>1000 V<br>1000 V*<br>ranges > 350 mV, 1000 V*<br>ranges < 350 mV, 350 V<br>*1500 V Max Peak |
| **Typical Recovery Time** | 1.5 s, 10 dB Overload<br>4.5 s, 20 dB<br>8.0 s, 30 dB<br>10.0 s, 40 dB<br>13.0 s, 50 dB | |
| **Common Mode Rejection** | > 120 dB at 1 kHz | |
| **Response** | Average, calibrated in RMS of a sine wave | |
| **Indicator** | Taut-band. Five inch logarithmic voltage scales, 1 to 3.5 and 3 to 10.<br>Linear decibel scale, 0 to 10 dB. | |
| **Input** | BNC coaxial, convertible to binding posts.<br>Separate signal and case grounds for isolated or above-ground operations. | |
| **Input Impedance** | 10 MΩ \|\| 15 - 25 pF | 10 MΩ \|\| 8 pF<br>(25 pF without probe) |
| **AC Amplifier** | Gain 40 dB ±0.5 dB, 2 Hz - 6 MHz. FS output 0.1 V.<br>Source resistance 150 Ω. Input noise < 30 μV. | |
| **Power Requirements**<br>Battery Use/Charge | Models 303 and 303-50, Rechargeable Battery/Line.<br>Models 303-01 and 303-51, Line Only, 120/240 V, 50 - 420 Hz, 5 W<br>30 hours use for 14 hours charge. | |
| **Color** | Light gray panel, charcoal gray case. | |
| **Dimensions** | 6.1 H x 7.8 W x 10.2 D inches. (15,5 H x 19,8 W x 25,9 D cm) | |
| **Weight** | Models 303 and 303-50: 8 lbs (3,6 kg) net, 12 lbs (5,4 kg) shipping<br>Models 303-01 and 303-51: 7 lbs (3,2 kg) net, 11 lbs (5,0 kg) shipping | |
| **Optional Accessories** | Model 1301 10 kV Probe<br>Model 600 Resistors for current measurements from 10 μA to 10 A | Model 1301 without 1303 Probe<br>Model 600 without 1303 Probe<br>Model 6314 Adapter to convert 1303 Probe to N/BNC |
| **Rack Mounting** | Model 800 Rack Mounting Kit will accommodate 1 or 2 Model 303 (or other BL half-rack instruments) for 7x19" rack mounting without modification. | |

# 2. OPERATION

## 2.1 Function of Controls

**MODE Switch** (Models 303 and 303-50 — See Fig. 3a)

| | |
|---|---|
| OFF | Turns the instrument off. |
| BATT 13 V | Indicates the battery's state of charge—below 13 V, indicates battery recharging is necessary —above 16.8 V, indicates that the battery is at full charge. For most accurate check, allow instrument to operate for 15 minutes before reading condition of battery. |
| METER | The instrument operates as a voltmeter. |
| METER +10 dB | The instrument operates as a voltmeter with an increase in sensitivity of 10 dB or 3 times that indicated by the range switch. |
| AMP | The instrument operates as a wideband amplifier with the indicator disconnected. |

(Models 303-01 and 303-51 — See Fig. 3b)

| | |
|---|---|
| OFF | Turns the instrument off. |
| METER | The instrument operates as a voltmeter. |
| METER +10 dB | The instrument operates as a voltmeter with an increase in sensitivity of 10 dB or 3 times that indicated by the range switch. |
| AMP | The instrument operates as a wideband amplifier with the indicator disconnected. |

**RANGE Switch** Selects the full scale voltage range in METER and METER +10 dB modes. Changes amplifier gain in 10 dB steps in amplifier mode.

**Power Selector** (Models 303 and 303-50)

| | |
|---|---|
| BATT | The instrument operates from internal batteries. |
| CHG | The instrument operates from line power, also the internal battery is recharged. Full recharge takes 15 hours. |
| LINE | The instrument operates from line power. The internal battery is disconnected from the circuit. |

**DAMPING Selector**

| | |
|---|---|
| LOW | Use for signal voltages above 10 Hz. |
| HI | Use below 10 Hz to reduce meter flutter to an acceptable limit. |

## 2.2 Power Connections

The instrument is supplied ready for operation on 105 to 130 V or 210 to 260 V, 50 Hz to 420 Hz, as indicated by the decal located on the back of the instrument.

### 2.2.1 Line Voltage Conversion

To change the line voltage of the instrument, proceed as follows:

(A) Remove the instrument's rear cover.

(B) Locate the line voltage switch on the upper right hand corner of the printed circuit board next to the line cord.

(C) Move the switch down for 120 V operation, up for 240 V operation.

(D) If the voltage chosen in step (C) does not agree with the decal, revise the marking to avoid damage to the instrument by applying improper line voltage

## 2.3 Indicator Linearity Adjustment (on rear panel), see Fig. 4

With the MODE switch in the METER position, the linearity adjustment affects the down scale indication. It is used to insure that bottom scale on one range corresponds to full scale on the next lower range.

## 2.4 Battery Indicator Adjustment (on rear panel) — 303 and 303-50.

This control calibrates the indicator to read the battery voltage when the MODE switch is in the battery test position.

## 2.5 Connectors

| | |
|---|---|
| **Input** | BNC connector located on front of instrument. May be converted to binding post with the Model 618 adapter supplied. |
| **Amplifier Output** | BNC connector located on rear of instrument. See Fig. 4. |

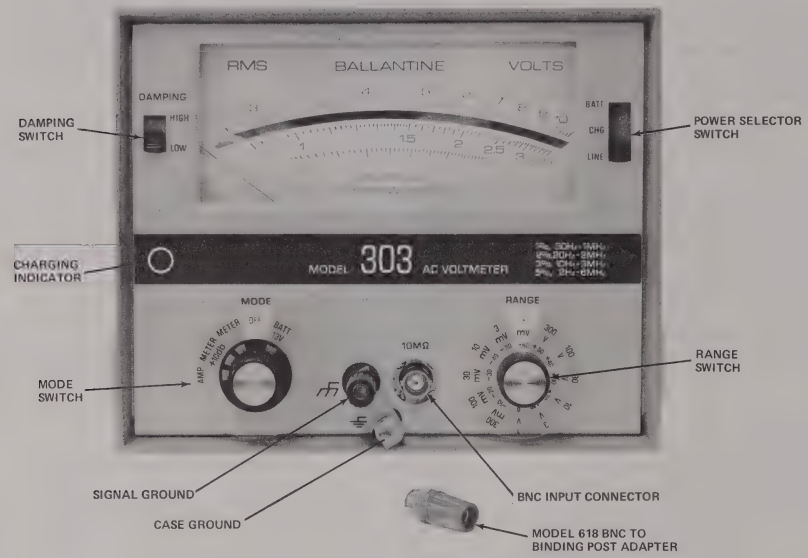



**Fig. 3a. Location of Controls — Model 303**

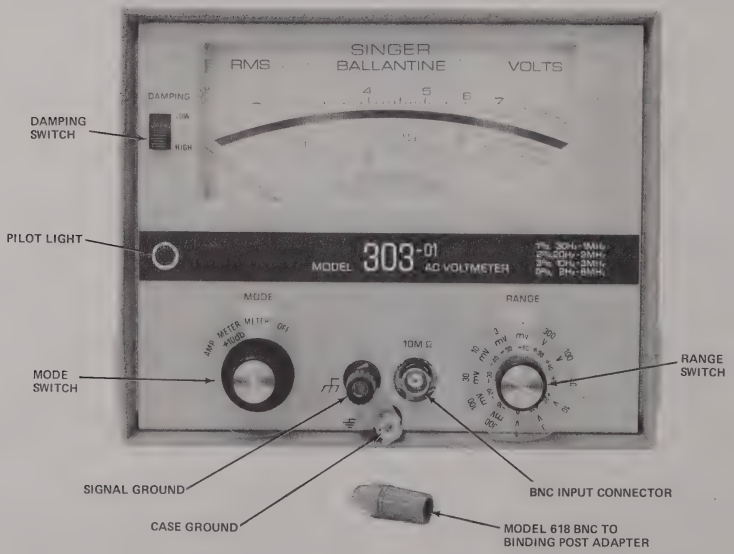



**Fig. 3b. Location of Controls — Model 303-01**

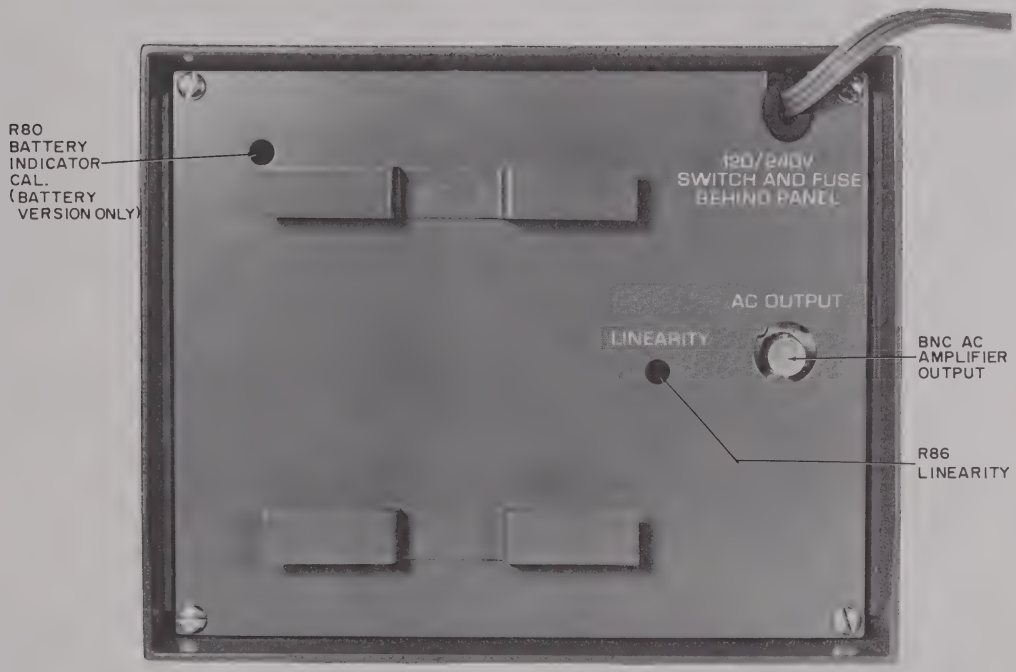



**Fig. 4. Model 303 Rear Panel**

## 2.6 Grounds

**Signal Gnd** Binding post located on front panel, connected to BNC shell.

**Case Gnd** Screw post located on front panel. Normally isolated from the signal ground by 100 MΩ in parallel with 600 pF. To connect the instrument's signal ground to the case ground, place a strap between the two posts on front panel.

**Power Cord Third Prong** Third prong is connected to voltmeter case ground.

## 2.7 Starting Procedure (Models 303 and 303-50)

### 2.7.1 Battery Operation

| Set | To |
|---|---|
| Power Selector | BATT |
| MODE Switch | METER |
| RANGE Switch | proper range |

### 2.7.2 Line Operation Insert Power Plug and

| Set | To |
|---|---|
| Power Selector | LINE |
| MODE Switch | METER |
| RANGE Switch | proper range |

### 2.7.3 Battery Charge Insert Power Plug and

| Set | To |
|---|---|
| Power Selector | CHG |
| MODE Switch | METER, METER +10 dB or AMP |
| RANGE Switch | 300 V* |

*NOTE: The voltmeter will operate as a line operated instrument during battery charging, therefore if the instrument is not to be used, set the RANGE switch to one of the higher ranges to keep the indicator from fluctuating with any noise pickup.

## 2.8 Starting Procedure (Models 303-01 and 303-51)

Insert power plug to proper line voltage and connect signal to the input connector. Allow 10 minutes warmup for accurate measurements.

| Set | To |
|---|---|
| MODE Switch | METER |
| RANGE Switch | proper range |

## 2.9 Voltage Measurements

The Model 303 is a wideband voltmeter and therefore sensitive to stray pickup. Great care has to be taken with the connecting cables, especially when low level and high frequency measurements are being made. Use coaxial connections whenever possible.

### 2.9.1 Isolated Case Measurements

With equipment mounted in a relay rack, power frequency ground currents are often a problem. The Model 303 signal ground can be isolated from the case ground to break up the ground current path. The 60 Hz impedance is greater than $-j5$ MΩ between the two instrument grounds.

**Isolated Measurements (303 and 303-50)**

For a truly isolated measurement use battery operation with the power cord disconnected from the line and wound on the brackets located on the rear of the instrument.

A typical test setup with the instrument on a wooden bench and isolated by approximately two feet from the nearest metal object will have a distributed capacity of less than 10 pF. The stray currents will therefore be very small even at the highest operating frequency of the instrument.

### 2.9.2 Video Measurements

At the higher video frequencies the loading by the input impedance of the voltmeter is appreciable. The input capacity above 30 mV is 15 pF at the input terminals; add to this approximately two feet of coaxial connecting cables and the total capacity is over 40 pF. At 6 MHz this represents a load of $-j650$ Ω.

If the Model 1303 20 dB Probe is used with either the Model 303-50 or 303-51, the loading capacity is reduced to 8 pF. This represents a load of $-j3000$ Ω to the circuit under test.

### 2.9.3 Noise Measurements

For accurate measurements of highly distorted signals or noise, the Ballantine True RMS Voltmeter Model 323 is recommended.

However, for relative measurements or if random noise is to be measured, the Model 303 may be useful. If the voltage to be measured is white noise with an approximate Gaussian distribution, and the noise bandwidth does not exceed 10 MHz a good approximation to the true RMS voltage is obtained by adding 13% to the indicated voltage. One should be careful

not to overload the amplifiers of the Model 303 when measuring noise. Readings should, if possible, be taken from down scale indications only.

### 2.9.4 dB Scale

The dB scale on the Model 303 is based on the dBV reference (1 mW into 1000 Ω). The dBV level may be converted to other reference levels by using the conversion figures shown in Table I.

**TABLE I**

| dB REFERENCE CONVERSION | |
|---|---|
| Reference Level | db Conversion |
| 0.775 V, 1 mW in 600 Ω | Add 2.219 dB |
| 1.732 V, 6 mW in 500 Ω | Subtract 4.761 dB |
| 1.897 V, 6 mW in 600 Ω | Subtract 5.561 dB |

### 2.10 Sources of Error

Because of the wide frequency range and high sensitivity of the Model 303, measuring errors may be a problem. Some of the most common error sources are listed below.

#### 2.10.1 Harmonic Effect

The Model 303 is calibrated in rms of a sine wave but is average responding. Measurement errors can occur when such an average responding instrument is used to measure highly distorted signals. The error depends upon the amplitude, phase and frequency of the harmonic distortion. Shown in Fig. 5 are plots of the relative error vs. the % harmonic.

#### 2.10.2 Ground Current Errors

Ground currents can introduce considerable measurement error. These currents are of signal power or other frequency flowing in the ground lead impedance, and appear as voltages at the input terminals of the voltmeter along with the desired signal.

The ground current errors may be reduced or eliminated by

(A) Eliminating or reducing the source of the ground current.

(B) Using an isolation transformer which will effectively reduce low frequency ground currents.

(C) Using coaxial connecting cables to lower the ground impedance and therefore reduce the errors to an acceptable value.

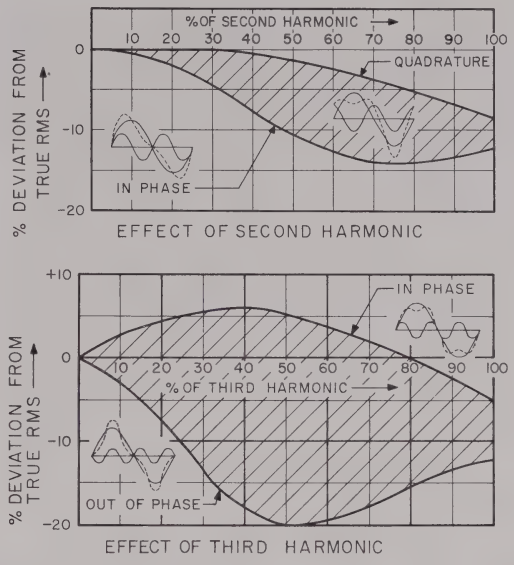



**Fig. 5. % Deviation from RMS — 2nd and 3rd Harmonics**

(D) Operating the Model 303 on batteries with the power cord wound on the brackets located on the back of the instrument.

#### 2.10.3 Input Impedance (Loading)

The input impedance of the Model 303 depends upon the setting of the range switch and the frequency of the signal being measured.

(A) Models 303 and 303-01, 30 mV range and below

| | |
|---|---|
| Capacitance | 25 pF |
| Resistance | See Fig. 6 |

(B) Models 303 and 303-01, 100 mV range and above

| | |
|---|---|
| Capacitance | 15 pF |
| Resistance | See Fig. 6 |

(C) Models 303-50 and 303-51, all ranges

| | |
|---|---|
| Capacitance | 8 pF |
| Resistance | See Fig. 6 |

#### 2.10.4 Magnetic and Electrostatic Fields

Strong magnetic or electrostatic fields may cause measurement errors. To reduce their effect, either shield the voltmeter or remove it from the strong field.

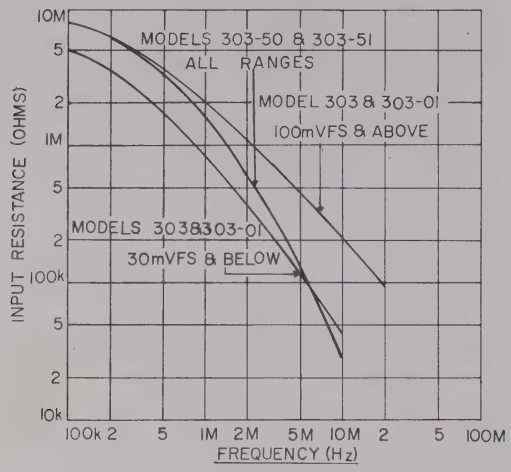



**Fig. 6. Input Resistance vs. Frequency**

### 2.10.5 Battery Voltage Effect (Model 303 Only)

If the battery voltage falls below 13 V, large errors in indication will be present. Recharging the batteries or operating from the line will correct this situation.

When the Model 303 is operated on internal batteries the following performance can be expected:

#### 2.10.5.1 Battery Voltage vs. Time

The battery voltage vs. time curve is shown in Fig. 7. The curve is made up of three sections:

(A) Initial discharge, which lasts for about three hours.

(B) Linear discharge, which constitutes the largest percentage of the discharge cycle, as well as the section where the greatest instrument accuracy is obtained.

(C) Final discharge, where the voltage drops rapidly to the discharge limit voltage. Discharging the battery below this limit will greatly reduce the number of recharge cycles of the battery.

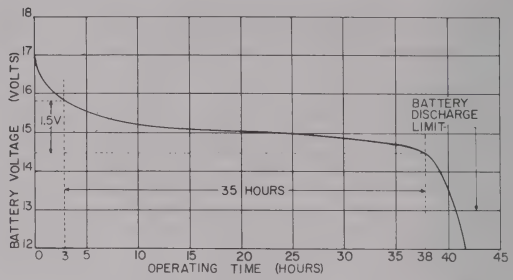



**Fig. 7. Battery Voltage vs. Operating Time**

Use the battery test position on the MODE switch to accurately determine the battery voltage. Refer this voltage to the above curve to estimate the number of operating hours remaining before recharge. For most accurate check, allow instrument to operate for 15 minutes before reading condition of battery.

#### 2.10.5.2 Typical Battery Voltage Effect on Instrument Accuracy

The following two curves show the effect on accuracy of varying the battery voltage.

(A) 1 kHz curve shows that the instrument stays well within the specified accuracy limit over the full battery voltage range of 13 V to 16.8 V DC. However, over the linear discharge voltage region, the effect is less than 0.3% indication error. See Fig. 8.

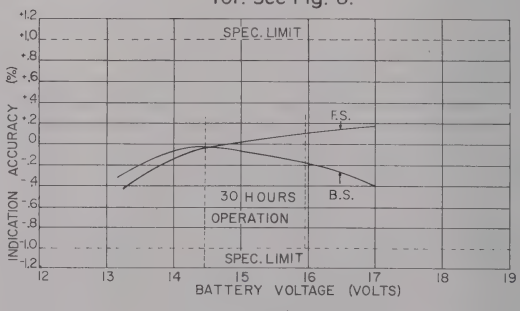



**Fig. 8. 1 kHz Accuracy vs. Battery Voltage**

(B) 1 MHz curve demonstrates that the instrument stays well within the specified accuracy limits. See Fig. 9.

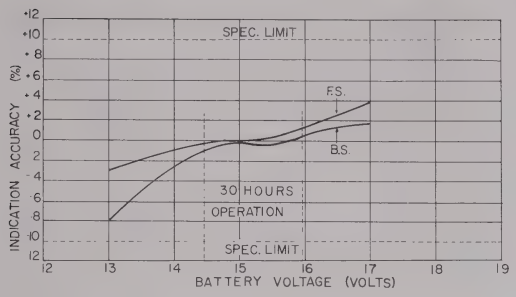



**Fig. 9. 1 MHz Accuracy vs. Battery Voltage**

### 2.11 Current Measurement

Use the Ballantine Series 600 Precision Shunt Resistors to accurately measure ac currents from 1 mA to 10 A. These and other accessories are described in the general Ballantine catalog.

### 2.12 Use as an Amplifier

The voltmeter may be used as a stable, wide band amplifier.

| Set | To |
|---|---|
| MODE Switch | AMP |
| RANGE Switch, 303 and 303-01 | 1 mV |
| 303-50 and 303-51 | 10 mV |

With the above setting of the controls the instrument will have the following specifications:

| | |
|---|---|
| Gain, 303, 303-01 | +40 dB |
| Gain, 303-50, 303-51 | +20 dB |
| Bandwidth | 2 Hz to 6 MHz |
| Accuracy | ±0.5 dB |
| Z out | 150 Ω |
| Noise (coaxial input) | 40 μV input open circuit (shielded) |
| | 30 μV input short circuit |

## 3. CIRCUIT DESCRIPTION

The basic circuitry of the Model 303 is shown in the simplified schematic, Fig. 10. A more complete schematic is located at the end of this manual. Following the signal through the circuit, the signal is attenuated as required, then amplified by the input amplifier (>60 dB power gain), attenuated again as necessary and amplified by the output amplifier (600 μA ac output for 10 mV ac input). The ac output is detected and the dc current displayed on the logarithmic indicator.

The basic sensitivity of the Model 303 is 1 mV full scale. To measure higher level signals a pair of attenuators reduces the level to 1 mV. Following is a table of the attenuation schedule.

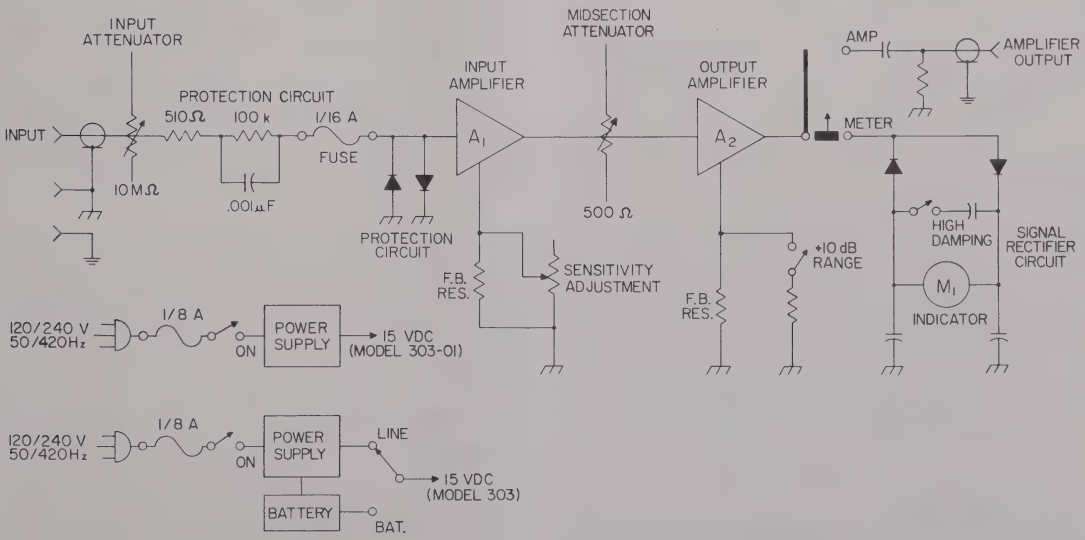



**Fig. 10. Simplified Schematic**

**TABLE II**

| ATTENUATION RATIOS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| VOLTAGE RANGE FULL SCALE | INPUT ATTENUATOR | | MIDSECTION ATTENUATOR | | TOTAL ATTENUATION | | AMP ATTENUATOR | |
| | RATIO | dB | RATIO | dB | RATIO | dB | RATIO | dB |
| 1 mV | 1 | 0 | 1 | 0 | 1 | 0 | +100 | +40 |
| 3 mV | 1 | 0 | 3.16 | 10 | 3.16 | 10 | +31.6 | +30 |
| 10 mV | 1 | 0 | 10 | 20 | 10 | 20 | +10 | +20 |
| 30 mV | 1 | 0 | 31.6 | 30 | 31.6 | 30 | +3.16 | +10 |
| 100 mV | 31.6 | 30 | 3.16 | 10 | 100 | 40 | 1 | 0 |
| 300 mV | 31.6 | 30 | 10 | 20 | 316 | 50 | .316 | −10 |
| 1 V | 31.6 | 30 | 31.6 | 30 | 1000 | 60 | .1 | −20 |
| 3 V | 1000 | 60 | 3.16 | 10 | 3160 | 70 | .0316 | −30 |
| 10 V | 1000 | 60 | 10 | 20 | 10,000 | 80 | .01 | −40 |
| 30 V | 1000 | 60 | 31.6 | 30 | 31,600 | 90 | .00316 | −50 |
| 100 V | $31.6 \times 10^3$ | 90 | 3.16 | 10 | 100,000 | 100 | .001 | −60 |
| 300 V | $31.6 \times 10^3$ | 90 | 10 | 20 | 316,000 | 110 | .000316 | −70 |

### 3.1 Input Attenuator

The input attenuator is a 10 MΩ compensated attenuator providing attenuation of 0, 30, 60 and 90 dB. At low frequencies the attenuation ratio is determined by the resistors, at high frequencies by the capacitors. The crossover from resistive to capacitive attenuation is at 5 kHz.

### 3.2 Input Protection

The maximum input voltage reaching the input amplifier is determined by the protection circuit. Under overload conditions the following results are obtained:

(A) at low frequency the lowest impedance presented to a signal source is 100 kΩ (2 kHz and below) which allows a 350 V maximum input.

(B) From approximately 10 kHz to 6 MHz on the 30 mV range and below the 510 Ω resistor limits the input current. If a very large overload occurs the fuse will burn out, protecting the circuit. Maximum continuous input is 35 V.

(C) On the 100 mV range and above the input attenuator impedance limits the input to the amplifier allowing a maximum continuous input of 350 V.

### 3.3 Input Amplifier

The input amplifier is a three-stage feedback amplifier with a voltage gain of 20 dB and 36 dB of loop feedback. The power gain is 66 dB due to the large difference in impedance levels (10 MΩ input, 500 Ω output).

### 3.4 Midsection Attenuator

This is a tee-type attenuator of 500 Ω impedance level and attenuation levels of 0, 10, 20 and 30 dB. The attenuator is resistive over most of the frequency range with slight capacitive compensation at higher frequencies.

### 3.5 Output Amplifier

The output amplifier is a three-stage feedback amplifier which drives the signal rectifier with 600 μA ac for an input of 10 mV ac. The loop feedback is 46 dB for normal operation (MODE switch in "METER" position) but drops to 36 dB in the METER +10 dB mode.

### 3.6 Signal Rectifier Circuit

The signal rectifier circuit is a conventional, average responding detector with an output of 300 μA dc for a 600 μA ac input. Hot-carrier diodes are used for temperature stability and high frequency efficiency.

### 3.7 Power Supply

**Model 303**

The instrument may be either line power or battery operated. Line operation uses a conventional circuit with zener regulated output voltage. Battery operation relies on nickel cadmium cells to supply the dc supply voltage.

**Model 303-01**

Only line power operation is possible with the Model 303-01.

### 3.8 Model 1303 20 dB Probe

As supplied with Models 303-50 and 303-51, the Model 1303 20 dB Probe forms a compensated 10:1 voltage divider with the input impedance of the voltmeter. R103 adjusts low frequency attenuation. C101, C2 and C3 are used to adjust high frequency attenuation.

## 4. MAINTENANCE

The Model 303 is designed for extended trouble-free service and should seldom require servicing or maintenance. Continuous operation for several thousand hours may be anticipated without need for recalibration.

Periodic maintenance checks are described in this section. Section 5 contains more detailed service and troubleshooting information.

### 4.1 Required Equipment

(A) Stable, accurately-calibrated voltage source, with a voltage range of at least 100 $\mu$V to 100 V RMS and a frequency of 400 Hz or 1 kHz. The Ballantine Model 421A is recommended.

(B) An accurate high impedance ac voltmeter with an input voltage range of 1 mV to 100 V and a frequency range of 10 Hz to 1 MHz. The Ballantine Models 300H, 310B, 320A, 323 and 303 are recommended.

### 4.2 Recommended Periodic Checks

It is recommended that the checks outlined in this section be made every 2000 hours of operation or once a year. Severe operating conditions may require these checks to be made more often.

### 4.3 Indicator Linearity Adjustment

| Set | | To |
|---|---|---|
| MODE Switch | | METER |
| RANGE Switch | 303 and 303-01 | 100 mV |
| | 303-50 and 303-51 | 1 V |

Apply a full-scale 400 Hz - 1 kHz signal to the input of the Model 303. Adjust the amplitude to give an indication exactly at 10 (full scale indication) on the uppermost voltage scale.

Rotate the range switch to the next higher range. If the indication is not at 1.0 on the lower voltage scale (down scale indication) rotate the "LINEARITY ADJ" control on the rear of the instrument until the indication is 1.0. Repeat the procedure until full scale indication on one range agrees exactly with the down scale indication on the next range to within ±0.25%.

### 4.4 Attenuator

To check the attenuator accuracy at midband proceed as follows:

(A) On the most sensitive range apply a signal to produce a full scale reading of 10.

(B) Increase the signal in precise 10 dB (3.162) steps, advancing the range switch accordingly. Note the deviation from the initial indication on each range. They should agree to within ±0.25%.

(C) If the disagreement is greater than ±0.25%, see service and troubleshooting sections 5.5.7 and 5.5.8.

### 4.5 Sensitivity

Complete the checks outlined in sections 4.3 and 4.4, then:

| Set | | To |
|---|---|---|
| MODE Switch | | METER |
| RANGE Switch | 303 and 303-01 | 100 mV |
| | 303-50 and 303-51 | 1 V |

Apply a full-scale 400 Hz - 1 kHz signal to the input. Note the deviation from a full-scale reading. If greater than ±0.25%, adjust sensitivity control R27 to an on-line indication.

### 4.6 Input Noise Test

| Set | | To |
|---|---|---|
| MODE Switch | | AMP |
| RANGE Switch | 303 and 303-01 | 1 mV |
| | 303-50 and 303-51 | 10 mV |

Connect an ac voltmeter to the amplifier output connector. Short the Model 303 input terminals and observe the noise voltage as read on the ac voltmeter. If an RMS ac voltmeter is used no correction of the reading is necessary. However, if an average responding ac voltmeter is used add 13% to the indicated voltage to get the correct readings. To refer the noise voltage readings to the equivalent input noise voltage, divide the observed readings by 100 (amplifier gain — 40 dB). Repeat the above for both 100 kΩ and open circuit input terminations.

| Termination | RMS Volts output (Max) |
|---|---|
| Short | 3.0 mV |
| 100 kΩ (shielded) | 3.5 mV |
| Open (shielded) | 4.0 mV |

If the input noise is substantially greater than that shown, the input field effect transistor more than likely has been damaged, and is in need of replacement.

# 5. SERVICE AND TROUBLESHOOTING

## 5.1 General

In case of voltmeter malfunction, servicing by the user is feasible provided skilled personnel and recommended equipment are available and the procedures outlined below are followed. However, it should be pointed out that the described procedures are only simplified outlines of actual service and calibration as performed by Ballantine. Refined service and comprehensive calibration require accurate and special equipment which normally is not available to the user. Therefore, if trouble develops which cannot be corrected by simplified methods outlined here, or when most accurate calibration of the voltmeter is needed, it is recommended that the voltmeter be returned to Ballantine Laboratories for service and calibration. The instrument should in all cases be preceded by a letter giving the exact nature and symptoms of the trouble or the requested service.

For location of internal adjustments and component placement, refer to internal views shown in figures 13, 14 and 15.

## 5.2 Required Equipment

**5.2.1** An accurate (1%), high impedance dc voltmeter covering the range of 10 mV to 100 V. Ballantine Model 365 is recommended.

**5.2.2** An accurate (2%), low impedance dc ammeter covering the range of 10 mA to 100 mA. Ballantine Model 365 is recommended.

**5.2.3** An accurate (1-2%), sensitive, high impedance ac voltmeter covering the voltage range of 1 mV to 100 V and a frequency range of 10 Hz to 100 kHz. Ballantine Models 300H, 310B, 323 and 303 are recommended.

**5.2.4** A variable frequency generator or generators covering the frequency range of 2 Hz to 6 MHz, with an output of 1 mV to 10 V or higher.

**5.2.5** A wide band level monitor or monitors, covering a frequency range of 2 Hz to 6 MHz. The Ballantine Model 440 Micropotentiometer and the Ballantine Model 393 HF Transfer Voltmeter are recommended.

**5.2.6** An accurate (±0.15%) stable voltage source with a frequency of 400 Hz or 1 kHz and precisely selected voltages between 100 μV and 300 V rms. The Ballantine Model 421A is recommended.

**5.2.7** Metered Variac 0 to 130 V AC.

## 5.3 Routine Service Problems

### 5.3.1 Fuse Replacement

Remove the four screws and the rear panel of the instrument. The fuse is located in the upper right hand corner of the printed circuit board.

For 120/240 V AC operation use 1/8 A 3AG Slo-Blo.

Note: Investigate and correct the cause of fuse failure before replacing the fuse.

### 5.3.2 Line Voltage Conversion

Located next to the fuse (see 5.3.1) on the rear printed circuit board is the 120 V - 240 V AC line voltage switch. The upper position is for 240 V operation, the lower for 120 V operation.

### * 5.3.3 Pilot Light Replacement

To replace the pilot light (or charge indicator, see 5.3.4) remove the instrument's top cover. Located on the rear of the front panel is a spring loaded pilot light fixture. Remove from front panel and replace defective bulb.

| | | |
|---|---|---|
| Models 303, 303-50 | GE #1302 | 6 V, 50 mA |
| Models 303-01, 303-51 | GE #1835 | 55 V, 50 mA |

### 5.3.4 Battery (Models 303 and 303-50)

These versions are powered by a 15 V, 450 mAh nickel cadmium battery. The battery should give several thousands of hours of service without need for replacement. If replacement becomes necessary the instrument will operate as a line powered voltmeter while the new batteries are on order.

#### * 5.3.4.1 Charge Indicator

The GE #1302 pilot light bulb is placed in series with the battery charging circuit. In this way a positive indication is displayed that the battery is being charged. If the bulb does not light in the "CHARGE" mode of operation, see section 5.3.4.2

#### * 5.3.4.2 Charging Current Check

Remove the GE #1302 bulb from its socket and clip a dc mA meter across the pilot light terminals. For normal operation a current of 45 mA should be indicated. If the bulb doesn't light when replaced in its socket the bulb is defective.



*Applicable to older instruments.

#### 5.3.4.3 Battery Replacement

To remove the battery proceed as follows:

(A) Remove the voltmeter's top cover.

(B) Unsolder the two battery wires.

(C) Remove the four screws securing the battery case to the handle extrusion.

(D) Remove the battery from the case.

To install new batteries follow the above procedure in reverse order.

### 5.4 Troubleshooting

If it appears that the instrument is not operating properly, the possibility of misadjustment should be eliminated first. Sections 4 and 5 outline checks useful for this purpose.

A visual inspection for broken leads, components or other physical defects is sometimes a rapid method of locating a cause of a malfunction.

In most cases it is possible to isolate the trouble to a particular circuit or section of the instrument. The simplified schematic (Fig. 10) and the schematic located at the end of the manual are useful for this purpose.

#### 5.4.1 DC Voltage Check

In many instances a defective component can be readily located by a check of pertinent dc operating potentials. All important dc potentials are shown on the schematic at the rear of the manual. These are typical voltages with variations up to ±20% considered normal.

#### 5.4.2 Signal Tracing

Signal tracing is recommended when a check of the dc voltages does not isolate the malfunction. All important ac operating levels are shown on the schematic located at the rear of the manual. The troubleshooting chart located in the next section will prove helpful in locating malfunctions.

#### 5.4.3 Troubleshooting Chart

| Symptom | Possible Cause | Pertinent Section |
|---|---|---|
| Instrument inoperative | No power, fuse blown<br>120/240 line selector in 240 V position<br>Defective power supply | 5.3.1<br>5.3.2 |
| High error on lower part of the scale | Misadjusted linearity control R86, defective CR15, CR17 | 5.5.1.3, 5.5.1.4 |
| Instrument out of Calibration<br>(A) on all ranges at low frequency | Voltmeter in METER +10 dB position, R27 Sen. Adj. off<br>Defective CR15, CR17 | 5.5.4<br>5.5.1.2 |
| (B) on all ranges at frequencies above 1 MHz | Amplifier frequency response off, deteriorated transistor or component | 5.5.5 |
| (C) on all ranges except 1 mV | Defective resistor in the midsection attenuator | 5.5.8<br>Table II |
| (D) on two or three ranges at low frequencies | Defective resistor in input attenuator | 5.5.8<br>Table II |
| (E) Sequential ranges do not agree | Linearity control R86 misadjusted, defective CR15, CR17 | 5.5.1.3, 5.5.1.4 |
| High error at 60 Hz measurement | High ground currents<br>Hum pickup through input leads | 2.10.2 |
| High error at 120 Hz measurement | Defective power supply<br>Filter capacitor C51 | |
| Pointer sluggish | Defective C58 | |

## 5.5 Calibration Procedure

The following calibration procedure is similar to that used in the original calibration at Ballantine Laboratories. Great care has been taken with the construction and adjustment of the calibration equipment to eliminate errors due to waveform distortion, ground loops and stray coupling problems.

It is therefore necessary for the customer who anticipates calibration of the instrument to verify that his calibration setup is free from the above error sources.

A list of the required equipment is given in section 5.2.

The Model 303 should be operated from 120/240 V line power during calibration. One hour warmup is suggested.

First, calibrate the Models 303-50 and 303-51 without the Model 1303 Probe. Then add probe as described in 5.5.9.

### 5.5.1 Sensitivity and Linearity Adjustments

#### 5.5.1.1 Equipment

Ballantine Model 421A with Model 2421 Error Computer, or equivalent.

3 ft. coaxial cable.

#### 5.5.1.2 Sensitivity Adjustment

**Model 303**

| | |
|---|---|
| MODE Switch | METER |
| RANGE Switch | 10 mV (100 mV*) |
| DAMPING Switch | LOW |

*Models 303-50 and 303-51

**Model 421A**

| Set | To |
|---|---|
| MODE Switch | 1 kHz RMS |
| RANGE Switch | 10 mV |
| OUTPUT Voltage | 10.00 |
| Error Computer | 0.00 |

Connect the output of the 421A to the Model 303 using the coaxial cable. The Model 303 should read 10.0 full scale. If necessary, adjust the Error Computer for an on-line indication. The Error Computer indication should read less than ±1%. If not, adjust according to paragraph 5.5.1.4.

#### 5.5.1.3 Linearity

Reduce the Model 421A output to 3.162 mV and again adjust the Error Computer for an on-line indication of 1.00 on the bottom meter scale. The indicated error should again be less than ±1%. If not, adjust according to paragraph 5.5.1.4.

#### 5.5.1.4 Adjustments

The sensitivity and linearity adjustments are somewhat interdependent. Therefore care must be taken to insure that both adjustments are correct.

If the sensitivity and/or linearity adjustments are incorrect proceed in the following manner.

Adjust the sensitivity control R27 for an on-line indication at 10.0 mV. Next check the down scale linearity at 1.00. If incorrect, adjust R86 for an on-line indication. Recheck full scale. If off, repeat the two adjustments until both are correct.

### 5.5.2 Amplifier Frequency Response

The typical frequency response for the Model 303 is shown in Fig. 11. This response is typical for all ranges below the 100 V full scale range. The two highest ranges (100 V and 300 V) have the same general response with a less accurate specification above 3 MHz.

Equipment:

Sensitive DC Millivoltmeter 100 μV to 10 mV. Ballantine Model 365 is recommended.

Low-level, wide band level monitor. Ballantine Model 393 HF Transfer Voltmeter and Model 440 Micropotentiometer are recommended.

Low frequency, low distortion generator, distortion < 0.5% 2 Hz to 2 MHz.

High frequency, low distortion generator, 1 MHz to 6 MHz, distortion < 0.5%, output voltage 2 V into 50 Ω.

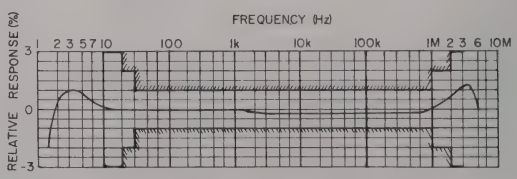



**Fig. 11. Typical Frequency Response**

### 5.5.3 Level Monitor

The test setup of equipment to check the frequency response on any range is shown in Fig. 12a and Fig. 12b. The connections between the Model 303 and the level monitor should be as short as possible. The signal generator and level monitor must operate at levels consistent with the range to be checked. For ranges up to 300 mV the Ballantine Model 440 is recommended as a level monitor. The Ballantine Model 393 is recommended for ranges 1 V to 100 V

### 5.5.4 Low Frequency Response

The low frequency response is determined primarily by the wide band amplifiers. A shift in the low frequency response usually indicates a faulty component. The low frequency response is adjusted in the following manner:

A. Connect the Model 303 as shown in Figure 12a, with the micropotentiometer output set to produce approximately 10.0 mV at 1 kHz. Adjust the signal level for an on-line indication (10.0 mV) on the Model 303 and note the indication on the level monitor.

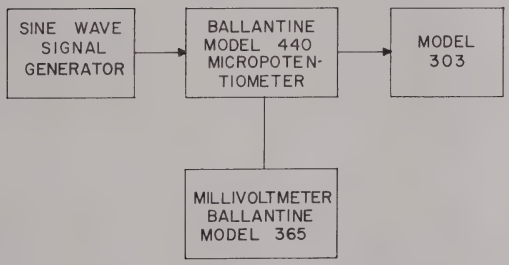



**Fig. 12a. Test Setup, 440**

B. In succession set the generator frequency to 100 Hz, 10 Hz, 6 Hz, 4 Hz, 3 Hz and 2 Hz, adjusting the amplitude at each frequency for the same indication on the level monitor as noted at 1 kHz. At each frequency note the instrument's deviation from the 1 kHz indication. The response should be similar to Figure 11 but always within the following specification limits:

| 1 kHz | Reference |
|---|---|
| 100 Hz | ±1% |
| 10 Hz | ±3% |
| 6 Hz | ±5% |
| 4 Hz | ±5% |
| 3 Hz | ±5% |
| 2 Hz | ±5% |

C. If the low frequency response is found to be out of specification a defective component should be suspected. (Changing a transistor or electrolytic capacitor may cause a shift in the frequency response.) This may be corrected as follows: Remove Resistor R28 and replace with a decade resistance box. Set the signal level to 10.0 mV and 3 Hz and adjust the decade resistance box to obtain approximately a 1% rise in the response. If this adjustment cannot be made with R28 values between 82 kΩ and 160 kΩ, change C32; to raise the response, decrease C32 (1 μF minimum); to lower the response, increase C32 (4.7 μF maximum).

D. Repeat the frequency response, taking data from 1 kHz to 2 Hz. The instrument response should be within specifications.

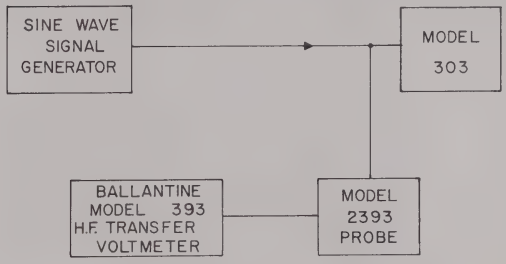



**Fig. 12b. Test Setup, 393**

### 5.5.5 High Frequency Response

The high frequency response is also determined on the 10 mV range. The same level monitors used in the low frequency are used at high frequency (see Fig. 12a).

A. Set the micropotentiometer output to a 10 mV, 1 kHz, on-line indication and note the level monitor reading.

B. In succession set the generator frequency to 10 kHz, 100 kHz, 1 MHz, 2 MHz, 3 MHz, 4 MHz, 5 MHz and 6 MHz, adjusting the amplitude at each frequency for the same indication on the level monitor as noted at 1 kHz.

C. At each frequency note the instrument's deviation from the 1 kHz indication. The response should be similar to that shown in Figure 11 but always within the following specified limits:

| 1 kHz | Reference |
|---|---|
| 10 kHz | ±1% |
| 100 kHz | ±1% |
| 1 MHz | ±1% |
| 2 MHz | ±2% |
| 3 MHz | ±3% |
| 6 MHz | ±5% |

D. If the high frequency response is found to be out of specification, proceed as follows:

#### 5.5.5.1 High Frequency Linearity

Connect the Model 303 to a signal source of 5 MHz which has an accurate 10 dB output attenuator. Adjust the generator for an on-line indication on the 10 mV range. Reduce the output by precisely 10 dB, noting the indication on the Model 303. If the down-scale indication (3.16 mV) is more than ±1% from the correct reading, C42 should be adjusted. If the error is positive the capacitor should be reduced in value, if negative the value should be increased. The approximate correction is 0.1 pF per 1% change required. A small grinding wheel is a convenient method to reduce the capacitance by small amounts.

#### 5.5.5.2 High Frequency Response

If the high frequency response is out of specification after the linearity adjustment, C41 can be adjusted to correct the response. The approximate adjustment is 1.5% per 100 pF change. Values for C41 above 500 pF have very little effect on the frequency response and therefore should not be used.

### 5.5.6 Attenuator (High Frequency Compensation Adjustment)

Precision metal film resistors are used in the Model 303 attenuator. These resistors are matched to within ±0.1% in resistance and ±100 ppm in temperature coefficient. Long-term aging will cause drifts of less than ±0.05%.

#### 5.5.6.1 Ranges — 3 mV, 10 mV, 30 mV

The midsection attenuator is resistive over most of the frequency range. Only the 30 mV range has an adjustment for high frequency compensation.

To check the 30 mV range proceed as follows:

A. Set the range switch to 30 mV. With the test setup of Fig. 12a, apply a 1 kHz signal to the instrument and adjust for a full scale on-line indication. Note the indication of the level monitor.

B. Increase the frequency to 5 MHz. Adjust the generator amplitude for the same level as at 1 kHz.

C. The Model 303 indication should be within ±2% of the indication at 1 kHz. If outside this limit, adjust C26 to bring the indication into limits.

#### 5.5.6.2 Ranges — 100 mV, 300 mV and 1 V

A. Set the range switch to 100 mV range. Apply 1 kHz signal to the instrument and adjust for a full scale on-line indication. Note the indication of the level monitor.

B. Increase the frequency to 100 kHz and adjust the generator amplitude for the same level as at 1 kHz.

C. The Model 303 indication should be the same as at 1 kHz within ±0.2%. If outside this limit, adjust C4 to bring the reading to within ±0.2%.

#### 5.5.6.3 Ranges — 3 V, 10 V and 30 V

A. Set the range switch to 3 V with the test setup of Fig. 12b, apply a 1 kHz signal to the instrument and adjust for a full scale on-line indication. Note the indication of the level monitor.

B. Increase the frequency to 100 kHz and adjust the generator amplitude for the same level as at 1 kHz.

C. The Model 303 indication should be within ±0.2% of the indication at 1 kHz. If outside this limit, adjust C6 to bring the indication into limits.

#### 5.5.6.4 Ranges — 100 V and 300 V

A. Set the range switch to 100 V with the test setup of Fig. 12b, apply a 1 kHz signal to the instrument and adjust for an on-line indication. Note the indication of the level monitor.

B. Increase the frequency to 5 MHz and adjust the generator amplitude for the same level as at 1 kHz.

C. The Model 303 indication should be within ±5% of the indication at 1 kHz. If outside this limit, adjust C8 to bring the indication into limits.

### 5.5.7 1 kHz Ranging Errors

A. Set the range switch to the 1 mV range. Apply a 1 kHz signal of precisely 1 mV to the instrument. Note the indication error on the Model 303.

B. Increase the signal level in precise 10 dB (3.162) steps, noting the Model 303 indication error on all ranges including the 300 V full scale range.

C. The indication error spread should be within ±0.2% on all ranges. If outside this limit see the next section.

### 5.5.8 Low Frequency Attenuator Adjustment

If the 1 kHz ranging test shows that any range is out-of-limits by more than ±0.2%, corrective measures should be taken. The following outlines the low frequency attenuator adjustment procedure.

#### 5.5.8.1 Midsection Attenuator Check— Ranges 3 mV, 10 mV and 30 mV

If the measured errors are positive, series resistors should be wired between the printed circuit board and the switch deck in place of the connecting wires. For negative errors the correction resistors should be wired in parallel with the existing resistors. For the proper value of resistor see Table III.

**TABLE III**

CORRECTION RESISTORS FOR MIDSECTION ATTENUATOR

| Range | Error % | Correction Resistor | Resistance Placement |
|---|---|---|---|
| 3 mV | $e > +0.1\%$ | $R_s = 100 \times e$ | In series with R40 |
| 10 mV | | | In series with R41 |
| 30 mV | | | In series with R42 |
| 3 mV | $e > -0.1\%$ | $R_p = \frac{840}{e}$ | Parallel to R40 |
| 10 mV | | $R_p = \frac{1500}{e}$ | Parallel to R41 |
| 30 mV | | $R_p = \frac{1750}{e}$ | Parallel to R42 |

#### 5.5.8.2 Input Attenuator — Ranges 100 mV, 300 mV and 1 V

If the errors in the 100 mV, 300 mV and 1 V ranges have the same deviation ($e > \pm 0.2\%$) only resistors R2, R3 and padder R4 are involved.

To correct the attenuation ratio, carefully unsolder the series padder R4 and measure its value. The new value is

$$R_4^* = R_4 \pm 3160\, e$$

where $R_4^*$ = New Value
$R_4$ = Measured value
$e$ = Error %

The new $R_4$ should be carefully soldered in place. An Allen-Bradley Type EB 5% unit is suitable.

#### 5.5.8.3 Input Attenuator — Ranges 3V, 10V and 30 V

If the errors on the 3 V, 10 V and 30 V ranges have the same deviation ($e > \pm 0.2\%$), replacing R7 will correct the error. The new padder value is

$$R_7^* = R7 \pm 100\, e$$

where $R_7^*$ = new value
R7 = measured old value
$e$ = error %

#### 5.5.8.4 Input Attenuator — Ranges 100 V and 300 V

If the errors on the 100 V and 300 V ranges have the same deviation ($e > \pm 0.2\%$), replacing R9 will correct the error. The new padder value is determined in the following manner:

Example:

100 V and 300 V Range Error
$e = +0.4\%$

Remove padder resistor R9 and measure R9 = 105 kΩ

Calculate shunt effect of R9 on R8 (R8 = 318 Ω)

$$\text{Shunt effect} = \frac{318 \times 100}{105\ \text{k}\Omega} = 0.3\%$$

Total shunting required of new padder
$e = +0.40 + 0.3 = 0.7\%$

New padder

$$R9^* = \frac{318 \times 100}{e\ \%} = \frac{31800}{0.7} = 45\ \text{k}\Omega$$

Use 47 kΩ 5% Allen-Bradley Type EB

### 5.5.9 Model 1303 Probe Calibration (Models 303-50 and 303-51)

The final calibration step for Models 303-50 and 303-51 consists of attaching and calibrating a Model 1303 Probe to an instrument which has already been calibrated according to the preceding sections.

A Model 1303 calibration requires adjusting both high frequency and low frequency controls as follows:

#### 5.5.9.1 Adjustment of C101

| Set | To |
|---|---|
| MODE Switch | METER |
| RANGE Switch | 300 mV |

Apply a 1 kHz signal to the probe sufficient to obtain a convenient meter indication. Maintaining this level, change the frequency to 100 kHz. Record the deviation versus the 1 kHz indication.

Detach the probe from the signal source and unscrew probe tip. With a narrow screwdriver, adjust C101 through the tip hole.

If deviation was +, turn trimmer clockwise. A quarter turn will change the response approximately 1%. If the deviation was −, turn the trimmer counterclockwise.

Replace the probe tip and repeat the measurements until the 1 kHz and 100 kHz measurements agree to within ±0.1%.

#### 5.5.9.2 Adjustment of R103

On same range, apply a known 1 kHz signal in the range of 100 - 300 mV to the probe input.

Adjust R103, accessible through the hole in the side of the probe, until the meter indication agrees with the signal applied.

#### 5.5.9.3 Adjustment of C2

Remove the top cover of the instrument.

| Set | To |
|---|---|
| RANGE Switch | 3 V |

Apply a 1 kHz signal to the probe sufficient to obtain a convenient meter indication. Maintaining this level, change the frequency to 100 kHz. Adjust C2, accessible through the attenuator shield on the right-hand side of the instrument, until the 1 kHz and 100 kHz indications agree to within ±0.1%.

#### 5.5.9.4 Adjustment of C3

| Set | To |
|---|---|
| RANGE Switch | 30 V |

Apply a 1 kHz signal to the probe sufficient to obtain a convenient meter indication. Maintaining this level, change the frequency to 100 kHz. Adjust C3, accessible through the attenuator shield on the right-hand side of the instrument, until the 1 kHz and 100 kHz indications agree to within ±0.1%.

## 6. SHIPPING INSTRUCTIONS

If it should be necessary to return the instrument to Ballantine Laboratories, please make certain that at least four inches of padding material surrounds the instrument to prevent damage during shipment. Ship via REA, UPS, motor truck, or air freight to:

*Ballantine Laboratories Inc.*
*90 Fanny Road*
*Boonton, New Jersey USA*

A letter describing the malfunction and/or the desired servicing should precede the instrument.

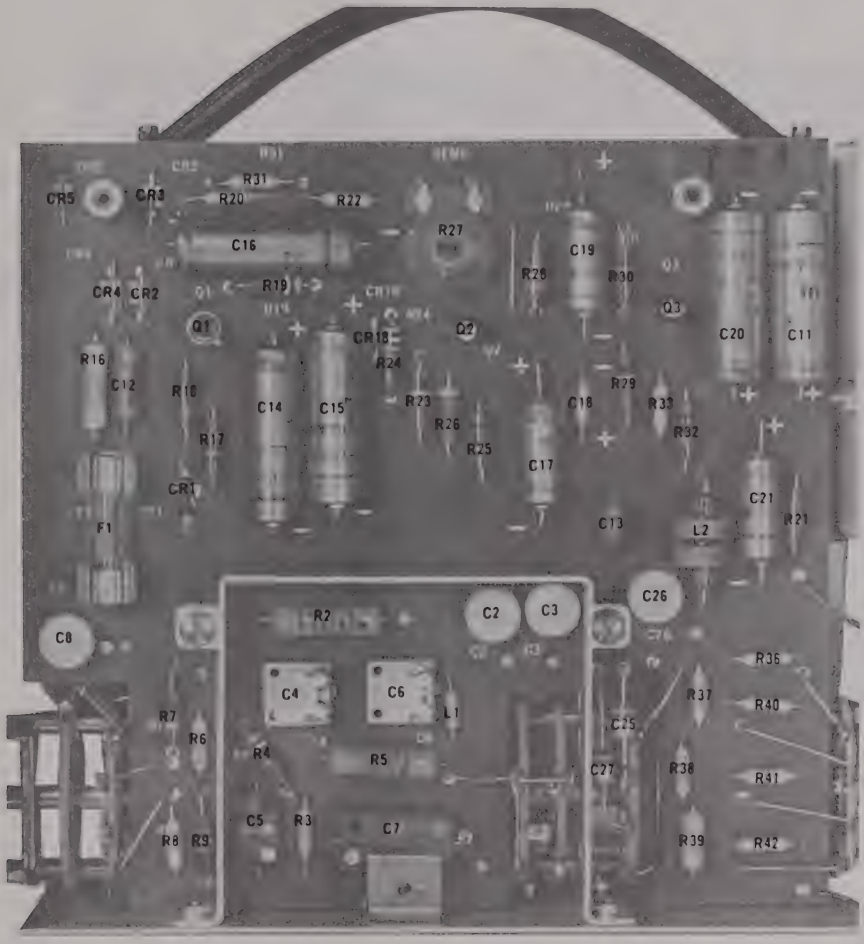



**Fig. 13. Attenuator Input and Amplifier — Right Side View**

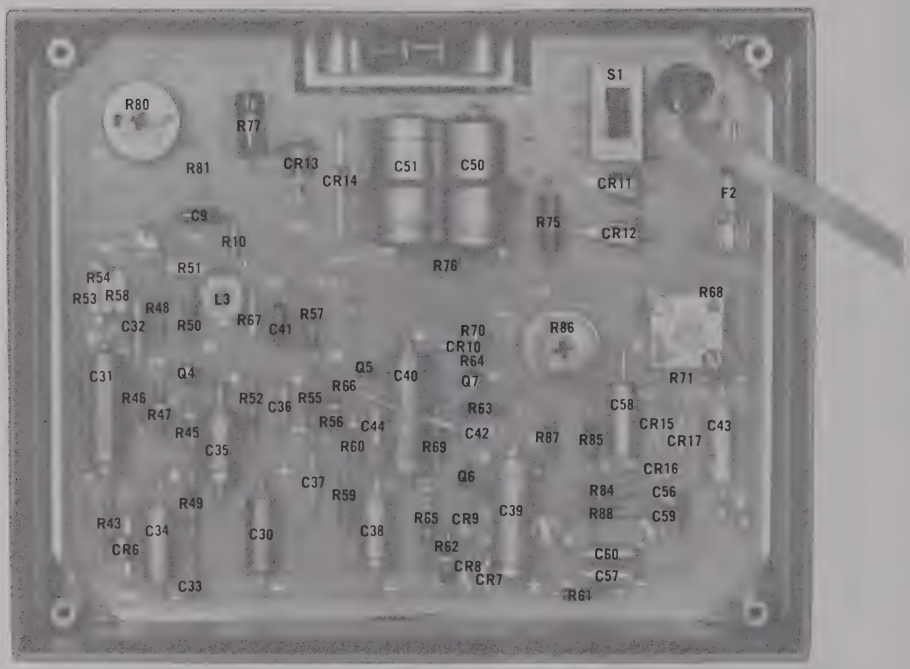



**Fig. 14. Output Amplifier and Power Supply — Rear View**

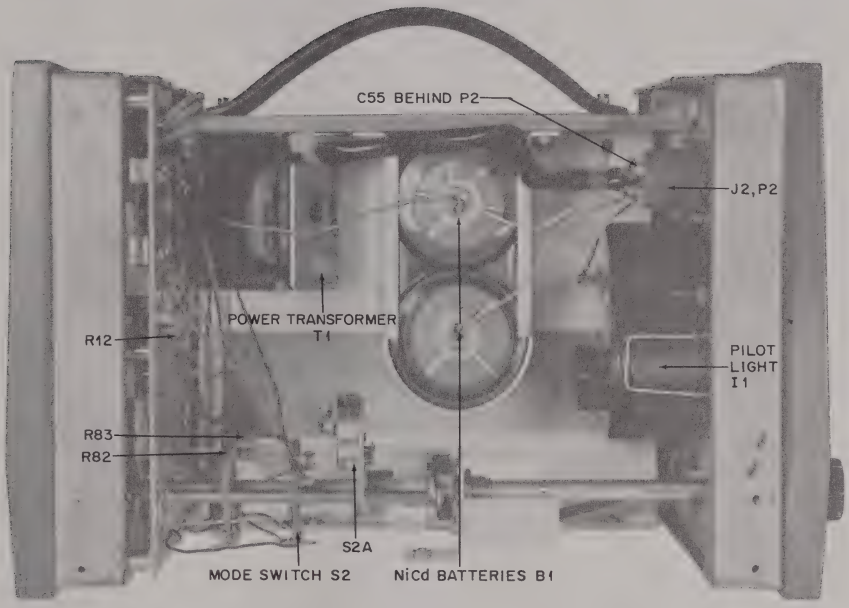



**Fig. 15. Mode Switch and Batteries — Left Side View**

## 7. REPLACEMENT PARTS LIST

REFER TO MODEL 303 SCHEMATIC DWG. ME-3536
or MODEL 303-01 SCHEMATIC DWG. ME-3543

| B. L. Part No. | Circuit Symbol | Capacitors | Manufacturer |
|---|---|---|---|
| 8125 | C1 | 0.27 μF, 600 V, Type 364 F 274 20 | Gudeman |
| 2449 | C2 | 2-8 pF, 350 V, Type NPO, Style 538-011 | Erie |
| 2449 | C3 | 2-8 pF, 350 V, Type NPO, Style 538-011 | Erie |
| 9153 | C4 | 1.2-4.2 pF, 850 V, Type 189-501-5 | Johnson |
| 2252 | C5 | 82 pF, 5%, Type CM-15-E-820-J | Arco |
| 2456 | C6 | 1.3-4.1 pF, 1300 V, Type 189-26-5 | Johnson |
| 2255 | C7 | 3300 pF, 5%, 500 V, Type CM-20-E-332-J | Arco |
| 2448 | C8 | 5.5-18 pF, 350 V, Type NPO, Style 538-011 | Erie |
| 2257 | C9 | 200 pF, ±10%, Type DM-15-201-K | Arco |
| 7827 | C11 | 250 μF, 16 V, Type C437AR/E250 | Amperex |
| 8119 | C12 | 0.001 μF, 10%, 600 V, Type 192P10296 | Sprague |
| 2541 | C13 | 0.01 μF, 10%, 500 V, Type 19C241 | Sprague |
| 7827 | C14 | 250 μF, 16 V, Type C437AR/E250 | Amperex |
| 7827 | C15 | 250 μF, 16 V, Type C437AR/E250 | Amperex |
| 7826 | C16 | 1000 μF, 2.5 V, Type C437AR/A1000 | Amperex |
| 7828 | C17 | 50 μF, 25 V, Type C426AR/F50 | Amperex |
| 7832 | C18 | 1 μF, 10%, 35 V, Type 150D | Sprague |
| 7828 | C19 | 50 μF, 25 V, Type C426AR/F50 | Amperex |
| 7827 | C20 | 250 μF, 16 V, Type C437AR/E250 | Amperex |
| 7828 | C21 | 50 μF, 25 V, Type C426AR/F50 | Amperex |
| 2596 | C25 | 1.1 pF, ±10%, Type QC | Quality Components |
| 2448 | C26 | 5.5-18 pF, 350 V, Type NPO, Style 538-011 | Erie |
| 2595 | C27 | 2.2 pF, ±10%, Type QC | Quality Components |
| 7828 | C30 | 50 μF, 25 V, Type C426AR/F50 | Amperex |
| 7827 | C31 | 250 μF, 16 V, Type C437AR/E250 | Amperex |
| 7838 | C32* | 3.3 μF, 20%, 6 V, Type 150D | Sprague |
| 2541 | C33 | 0.01 μF, 10%, 500 V, Type 19C241 | Sprague |
| 7828 | C34 | 50 μF, 25 V, Type C426AR/F50 | Amperex |
| 7828 | C35 | 50 μF, 25 V, Type C426AR/F50 | Amperex |
| 7832 | C36 | 1 μF, 10%, 35 V, Type 150D | Sprague |
| 2508 | C37 | 6.2 pF, ±5%, Type QC | Quality Components |
| 7828 | C38 | 50 μF, 25 V, Type C426AR/F50 | Amperex |
| 7826 | C39 | 1000 μF, 2.5 V, Type C437AR/A1000 | Amperex |
| 7827 | C40 | 250 μF, 16 V, Type C437AR/E250 | Amperex |
| 2257 | C41* | 200 pF, ±10%, Type DM-15-201-K | Arco |
| 2512 | C42 | 1.0 pF, 5%, Type QC | Quality Components |
| 7828 | C43 | 50 μF, 25 V, Type C426AR/F50 | Amperex |
| 7832 | C44 | 1 μF, 10%, 35 V, Type 150D | Sprague |
| 7829 | C50 | 250 μF, 40 V, Type C437AR/G250 | Amperex |
| 7833 | C51 | 1000 μF, 16 V, Type C437AR/E1000 | Amperex |
| 7826 | C55 | 1000 μF, 2.5 V, Type C437AR/A1000 | Amperex |
| 2541 | C56 | 0.01 μF, 10%, 500 V, Type 19C241 | Sprague |
| 7830 | C57 | 15 μF, 10%, 20 V, Type 150D | Sprague |
| 7828 | C58 | 50 μF, 25 V, Type C426AR/F50 | Amperex |
| 2541 | C59 | 0.01 μF, 10%, 500 V, Type 19C241 | Sprague |
| 7830 | C60 | 15 μF, 10%, 20 V, Type 150D | Sprague |
| 2541 | C61 | 0.01 μF, 10%, 500 V, Type 19C241 | Sprague |

## REPLACEMENT PARTS LIST (Continued)

REFER TO MODEL 303 SCHEMATIC DWG. ME-3536
or MODEL 303-01 SCHEMATIC DWG. ME-3543

| B. L. Part No. | Circuit Symbol | | Resistors | Manufacturer |
|---|---|---|---|---|
| 6099 | R1 | | 10.2 MΩ, 1%, Type N4 | Constanta |
| 6098 | R2[1] | | 9.684 MΩ, 0.5%, Type PME70 | Pyrofilm |
| 6081 | R3[1] | | 314.5 kΩ, 1%, Type MF5C | Electra |
| 1089 | R4* | | 3.3 kΩ, 5%, Type EB | Allen-Bradley |
| 6097 | R5[2] | | 10 MΩ, 0.5%, Type PME70 | Pyrofilm |
| 6084 | R6[2] | | 9.635 kΩ, 1%, Type MF5C | Electra |
| 1068 | R7* | | 100 Ω, 5%, Type EB | Allen-Bradley |
| 6089 | R8[2] | | 318 Ω, 1%, Type MF5C | Electra |
| 1037 | R9* | | 30 kΩ, 5%, Type EB | Allen-Bradley |
| 8007 | R10 | | 1.5 kΩ, 5%, Type CB | Allen-Bradley |
| 1066 | R11 | 303 only | 160 Ω, 5%, Type EB | Allen-Bradley |
| 8008 | R12 | | 100 Ω, 5%, Type CB | Allen-Bradley |
| 1282 | R15 | | 510 Ω, 5%, Type GB | Allen-Bradley |
| 7257 | R16 | | 100 kΩ, 1%, Type MF7C | Electra |
| 1136 | R17 | | 1.3 kΩ, 5%, Type EB | Allen-Bradley |
| 1054 | R18 | | 2 kΩ, 5%, Type EB | Allen-Bradley |
| 1065 | R19* | | 200 Ω, 5%, Type EB | Allen-Bradley |
| 8835 | R20 | | 48.7 Ω, 1%, Type MF5C | Electra |
| 1061 | R21 | | 510 Ω, 5%, Type EB | Allen-Bradley |
| 8823 | R22 | | 750 Ω, 1%, Type MF5C | Electra |
| 1026 | R23 | | 100 kΩ, 5%, Type EB | Allen-Bradley |
| 1036 | R24* | | 33 kΩ, 5%, Type EB | Allen-Bradley |
| 1057 | R25 | | 1 kΩ, 5%, Type EB | Allen-Bradley |
| 1048 | R26 | | 4.7 kΩ, 5%, Type EB | Allen-Bradley |
| 6873 | R27 | | 2 kΩ, ±30%, Type U-201 (High Torque) | CTS |
| 1139 | R28* | | 110 kΩ, 5%, Type EB | Allen-Bradley |
| 1026 | R29 | | 100 kΩ, 5%, Type EB | Allen-Bradley |
| 1042 | R30 | | 15 kΩ, 5%, Type EB | Allen-Bradley |
| 6087 | R31* | | 500 Ω, 1%, Type MF5C | Electra |
| 1057 | R32 | | 1 kΩ, 5%, Type EB | Allen-Bradley |
| 6085 | R33 | | 5 kΩ, 1%, Type MF5C | Electra |
| 6088 | R36[3] | | 341.9 Ω, 1%, Type MF5C | Electra |
| 6091 | R37[3] | | 108.1 Ω, 1%, Type MF5C | Electra |
| 6092 | R38[3] | | 34.19 Ω, 1%, Type MF5C | Electra |
| 6093 | R39[3] | | 15.81 Ω, 1%, Type MF52C | Electra |
| 8828 | R40[3] | | 304 Ω, 1%, Type MF5C | Electra |
| 8804 | R41[3] | | 405 Ω, 1%, Type MF5C | Electra |
| 8803 | R42[3] | | 438 Ω, 1%, Type MF5C | Electra |
| 1061 | R43 | | 510 Ω, 5%, Type EB | Allen-Bradley |
| 1048 | R45 | | 4.7 kΩ, 5%, Type EB | Allen-Bradley |

[1] Resistors R2, R3 are part of a matched set and must be purchased as Set No. 8863.

[2] Resistors R5, R6, R8 are part of a matched set and must be purchased as Set No. 8862.

[3] Resistors R36, R37, R38, R39, R40, R41, R42 are part of a matched set and must be purchased as Set No. 8864.

* In some instruments the component listed may not be used at all or its value may differ from the value shown.

## REPLACEMENT PARTS LIST (Continued)

REFER TO MODEL 303 SCHEMATIC DWG. ME-3536
or MODEL 303-01 SCHEMATIC DWG. ME-3543

| B. L. Part No. | Circuit Symbol | | Resistors | Manufacturer |
|---|---|---|---|---|
| 1040 | R46 | | 20 kΩ, 5%, Type EB | Allen-Bradley |
| 1026 | R47 | | 100 kΩ, 5%, Type EB | Allen-Bradley |
| 1042 | R48 | | 15 kΩ, 5%, Type EB | Allen-Bradley |
| 1054 | R49 | | 2 kΩ, 5%, Type EB | Allen-Bradley |
| 1106 | R50 | | 68 Ω, 5%, Type EB | Allen-Bradley |
| 6096 | R51 | | 13.5 Ω, 1%, Type MF52C | Electra |
| 1030 | R52* | | 51 kΩ, 5%, Type EB | Allen-Bradley |
| 8832 | R53* | | 68.1 Ω, 1%, Type MF5C | Electra |
| 6096 | R54 | | 13.5 Ω, 1%, Type MF52C | Electra |
| 1054 | R55 | | 2 kΩ, 5%, Type EB | Allen-Bradley |
| 1026 | R56 | | 100 kΩ, 5%, Type EB | Allen-Bradley |
| 1039 | R57* | | 22 kΩ, 5%, Type EB | Allen-Bradley |
| 6096 | R58 | | 13.5 Ω, 1%, Type MF52C | Electra |
| 1057 | R59 | | 1 kΩ, 5%, Type EB | Allen-Bradley |
| 1048 | R60 | | 4.7 kΩ, 5%, Type EB | Allen-Bradley |
| 1101 | R61 | | 15 Ω, 5%, Type EB | Allen-Bradley |
| 1026 | R62 | | 100 kΩ, 5%, Type EB | Allen-Bradley |
| 1115 | R63 | | 220 kΩ, 5%, Type EB | Allen-Bradley |
| 8005 | R64 | | 220 kΩ, 5%, Type CB | Allen-Bradley |
| 1062 | R65 | | 390 Ω, 5%, Type EB | Allen-Bradley |
| 6083 | R66 | | 10 kΩ, 1%, Type MF5C | Electra |
| 6090 | R67 | | 150 Ω, 1%, Type MF5C | Electra |
| 6090 | R68 | | 150 Ω, 1%, Type MF5C | Electra |
| 1048 | R69 | | 4.7 kΩ, 5%, Type EB | Allen-Bradley |
| 8006 | R70 | | 39 kΩ, 5%, Type CB | Allen-Bradley |
| 8829 | R71* | | 2.71 kΩ, 1%, Type MF5C | Electra |
| 1282 | R75 | | 510 Ω, 5%, Type GB | Allen-Bradley |
| 1063 | R76 | | 300 Ω, 5%, Type EB | Allen-Bradley |
| 1163 | R77 | 303 only | 470 Ω, 5 W, Brown Devil | Ohmite |
| 6854 | R80 | 303 only | 10 kΩ, 10%, Type 115 | CTS |
| 6082 | R81 | 303 only | 100 kΩ, 1%, Type MF5C | Electra |
| 1106 | R82 | | 68 Ω, 5%, Type EB | Allen-Bradley |
| 1106 | R83 | | 68 Ω, 5%, Type EB | Allen-Bradley |
| 1101 | R84 | | 15 Ω, 5%, Type EB | Allen-Bradley |
| 1040 | R85 | | 20 kΩ, 5%, Type EB | Allen-Bradley |
| 6854 | R86 | | 10 kΩ, 10%, Type 115 | CTS |
| 1040 | R87 | | 20 kΩ, 5%, Type EB | Allen-Bradley |
| 1101 | R88 | | 15 Ω, 5%, Type EB | Allen-Bradley |
| | | | **Other Components** | |
| 8602 | B1 | 303 only | Battery, 7.5 V, 450 mAH, NiCd, Type Y5462 | Union Carbide |
| 8602 | B2 | 303 only | Battery, 7.5 V, 450 mAH, NiCd, Type Y5462 | Union Carbide |
| 7937 | CR1 | | Diode, Zener ±5%, 11 V, Type HV 0667 | Hughes |
| 7932 | CR2 | | Diode, Type FD 777 | Fairchild |
| 7920 | CR3 | | Diode, Type 1N4148 | General Electric |
| 7932 | CR4 | | Diode, Type FD 777 | Fairchild |

* In some instruments the component listed may not be used at all or its value may differ from the value shown.

## REPLACEMENT PARTS LIST (Continued)

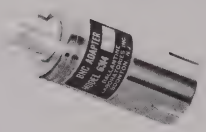
REFER TO MODEL 303 SCHEMATIC DWG. ME-3536
or MODEL 303-01 SCHEMATIC DWG. ME-3543

| B. L. Part No. | Circuit Symbol | | Other Components | Manufacturer |
|---|---|---|---|---|
| 7920 | CR5 | | Diode, Type 1N4148 | General Electric |
| 7937 | CR6 | | Diode, Zener ±5%, 11 V, Type HV 0667 | Hughes |
| 7920 | CR7 | | Diode, Type 1N4148 | General Electric |
| 7920 | CR8 | | Diode, Type 1N4148 | General Electric |
| 7920 | CR9 | | Diode, Type 1N4148 | General Electric |
| 7920 | CR10 | | Diode, Type 1N4148 | General Electric |
| 7921 | CR11 | | Rectifier, Silicon, Special | Ballantine |
| 7921 | CR12 | | Rectifier, Silicon, Special | Ballantine |
| 7921 | CR13 | 303 only | Rectifier, Silicon, Special | Ballantine |
| 7939 | CR14 | | Diode, Zener, Type 1N4744A, ±5%, 15 V | Motorola |
| 7942 | CR15 | | Diode, Type HPA 2900 | Hewlett-Packard |
| 7942 | CR17 | | Diode, Type HPA 2900 | Hewlett-Packard |
| 7920 | CR18 | | Diode, Type 1N4148 | General Electric |
| 2808 | F1 | | Fuse, 1/16 A, Type 8AG | Littelfuse |
| 2807 | F2 | | Fuse, 1/8, A, Slo-Blo, Type 3AG | Littelfuse |
| 3490 | I1 | | Bulb, Indicator, Type 2110A1 | Industrial Devices |
| 6265 | L1 | | Choke, 4.7 μH, ±10%, Type 9230-36 | Miller |
| 6268 | L2 | | Choke, 1 mH, Type 2965-7 | CTC |
| 6270 | L3 | | Coil, 0.05 μH, Special | Ballantine |
| 6271 | L4 | | Choke, RF, 15 μH, Type DD-15.0 | Nytronics |
| 6016 | M1 | | Microammeter, Logarithmic Type, 300 μA, 750 Ω | Ballantine |
| or 6026 | M1 | | Microammeter, Logarithmic Type, 300 μA, 530 Ω | Ballantine |
| 7933 | Q1 [1] | | Transistor, Type 2N4221A, Selected | Ballantine |
| 7926 | Q2 [1] | | Transistor, Type 2N3563, Selected | Ballantine |
| 7935 | Q3 | | Transistor, Type 2N3694 | Fairchild |
| 7935 | Q4 | | Transistor, Type 2N3694 | Fairchild |
| 7926 | Q5 | | Transistor, Type 2N3563, Selected | Ballantine |
| 7941 | Q6 | | Transistor, Type 2N4121 | Fairchild |
| 7935 | Q7 | | Transistor, Type 2N3694 | Fairchild |
| 7771 | S1 | | Switch, Slide, Type SS50 | Stackpole |
| 7767 | S2 | | Switch, Mode, Special | Ballantine |
| 7771 | S3 | | Switch, Slide, Type SS50 | Stackpole |
| 7768 | S4 | | Switch, Range, Special | Ballantine |
| 7770 | S4 | 303 only | Switch, Slide, Type SS54 | Stackpole |
| 6269 | T1 | | Transformer, Power, Special | Ballantine |
| 4156 | — | | AC Power Cord | Ballantine |

### MODEL 1303 20 dB ATTENUATOR PROBE

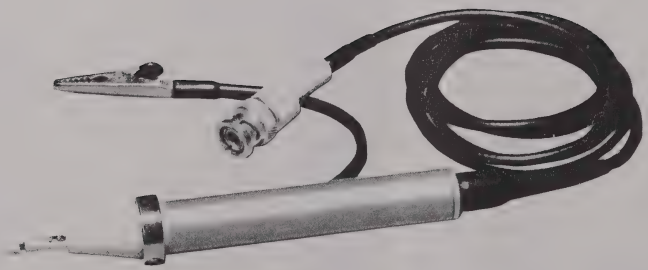
| | | | |
|---|---|---|---|
| 2445 | C101 | 0.7 - 9 pF, 1000 V, Piston Probe Trimmer | JFD |
| 8850 | R101 | 9.0 MΩ, ±1%, Type PME 62 | Pyrofilm |
| 8800 | R102 | 1.09 MΩ, ±1%, Type MF6C | Electra |
| 1937 | R103 | 250 kΩ, ±30%, Type 3 POS 10190 | Centralab |

[1] Transistors Q1, Q2 are part of a matched set and must be purchased as Set No. 7943.



**Model 6314 BNC Adapter**
(For attachment to Model 1303 Probe)

**Series 600**
**Precision Shunt Resistor**



**Model 1303 Probe**

**Fig. 16. Accessories for Model 303**
which may be purchased separately

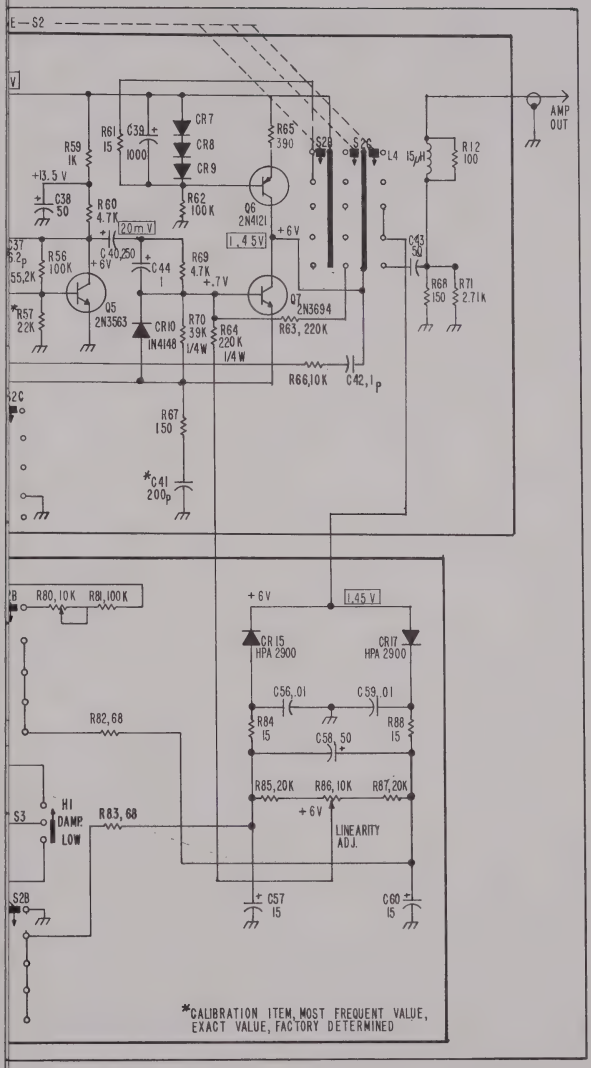
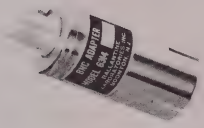
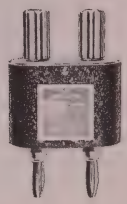


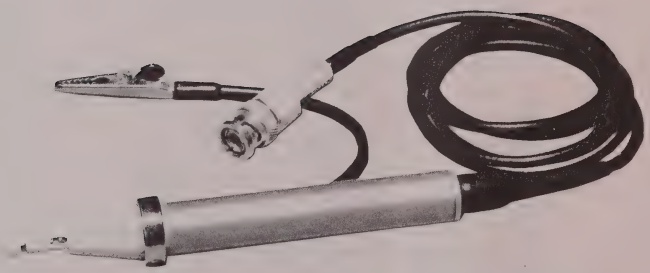

**Fig. 17**
**Wiring Diagram of Model 303 AC Voltmeter**



**Model 6314 BNC Adapter**
(For attachment to Model 1303 Probe)



**Series 600**
**Precision Shunt Resistor**



**Model 1303 Probe**

**Fig. 16. Accessories for Model 303**
which may be purchased separately

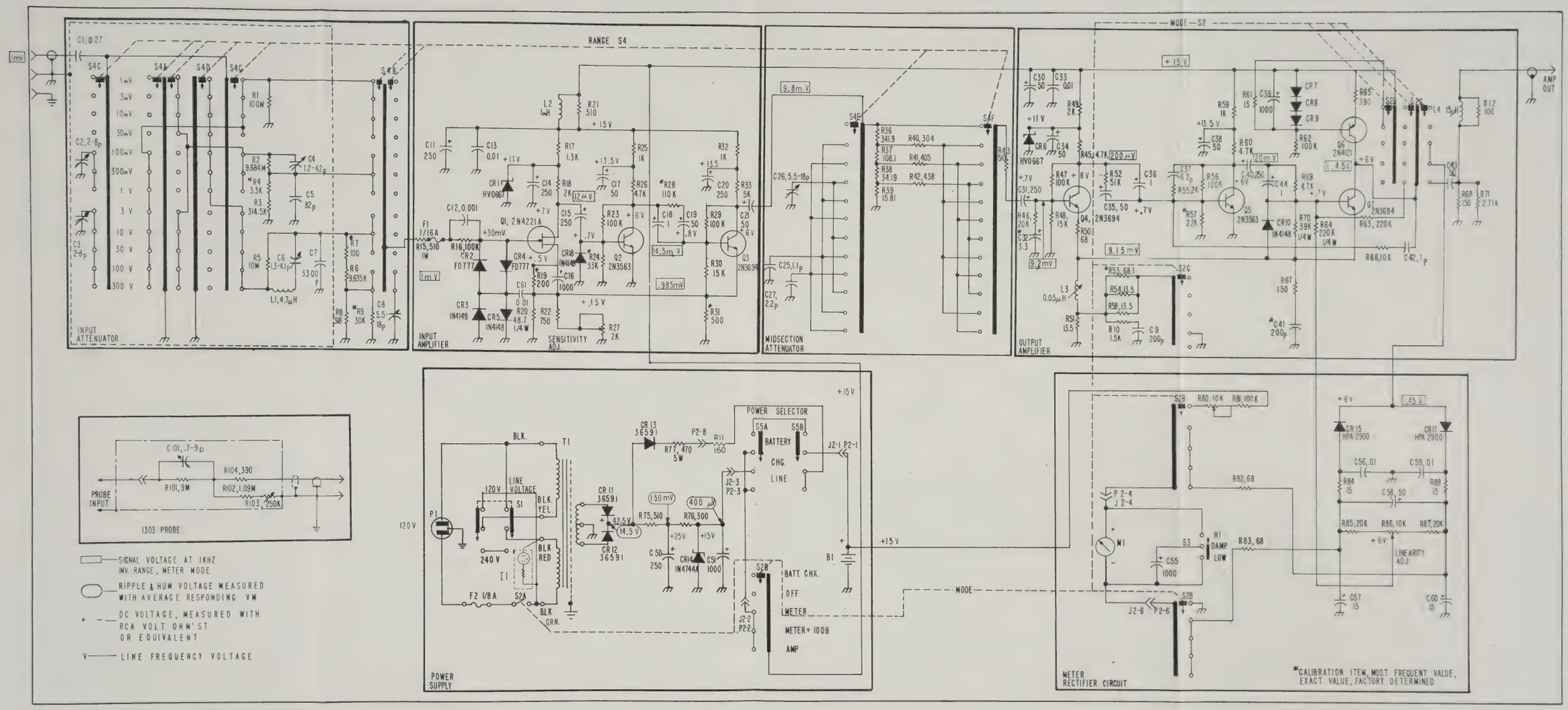



**Fig. 17**
**Wiring Diagram of Model 303 AC Voltmeter**

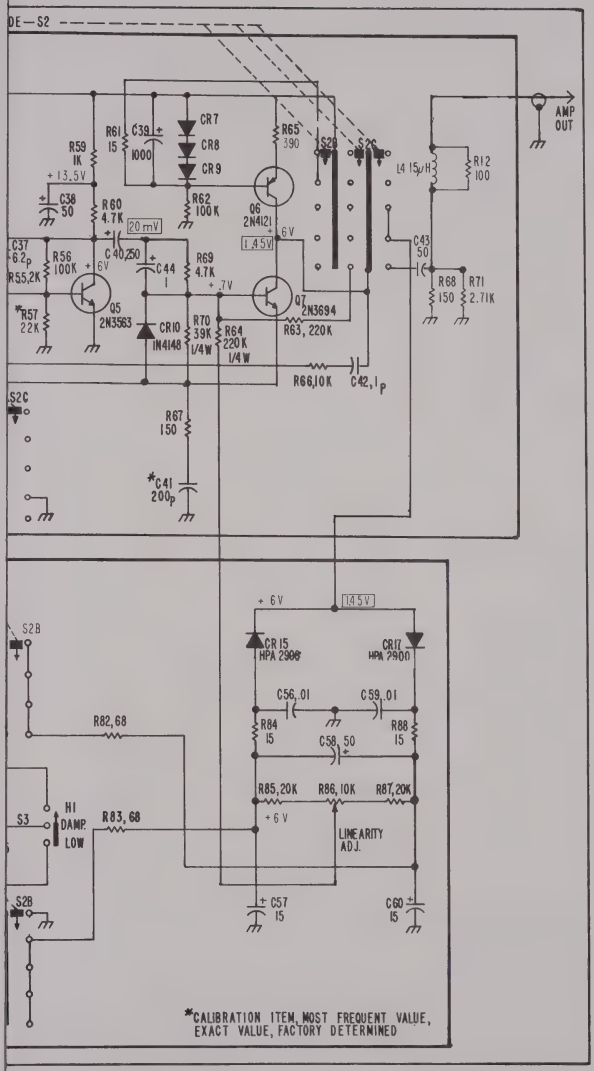
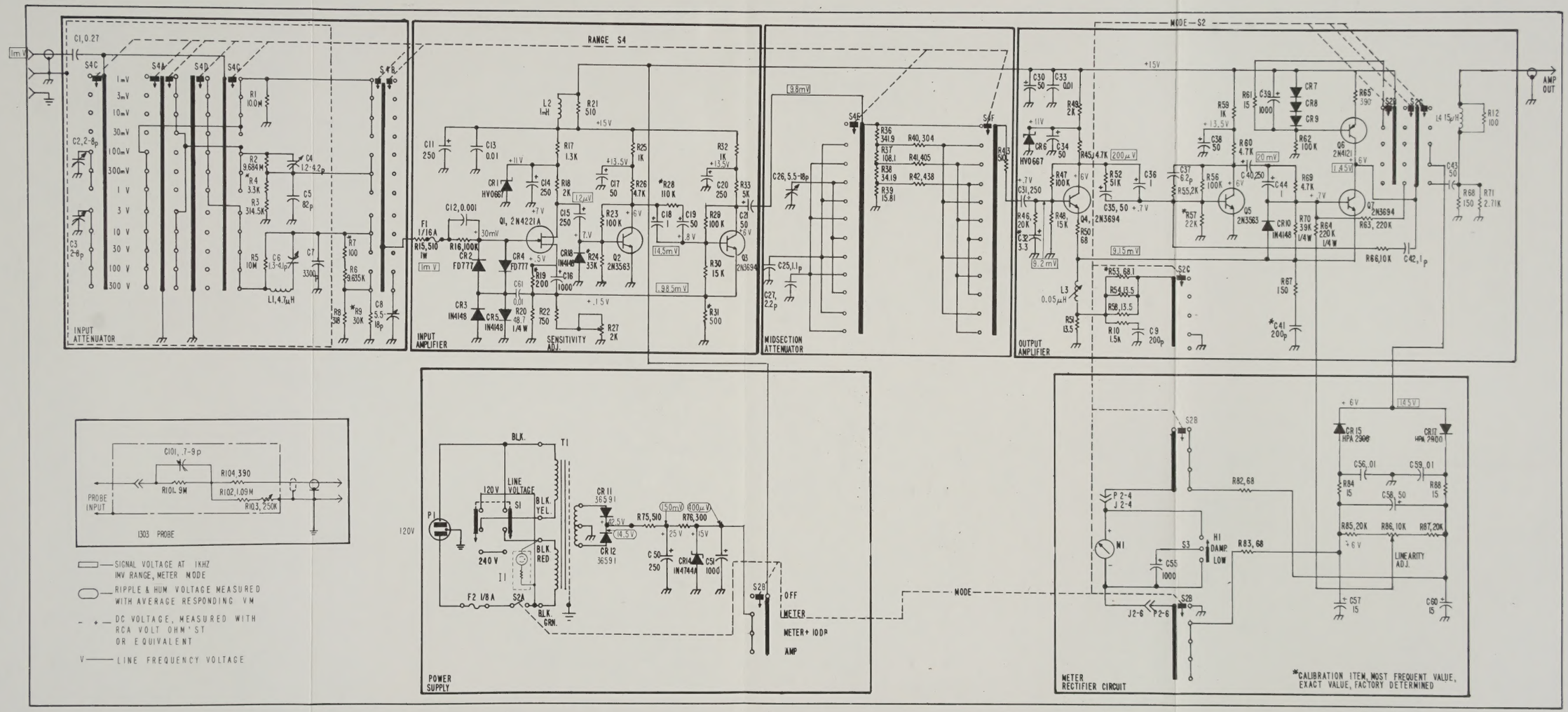



**Fig. 18**
**Wiring Diagram of Model 303-01 AC Voltmeter**




CAPACITORS: NOT MARKED — MICROFARADS ($10^{-6}$ F)
P — PICOFARADS ($10^{-12}$ F)
RESISTORS: NOT MARKED — OHMS (Ω)
K — KILOHMS ($10^{3}$ Ω)
M — MEGOHMS ($10^{6}$ Ω)
VOLTAGE: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS ($10^{-3}$ V)

Fig. 18
Wiring Diagram of Model 303-01 AC Voltmeter